United States
Department of
Agriculture

Animal and
Plant Health
Inspection
Service

DWRC
Research
Report
No. 11-55-003

Postharvest Grain Losses in Farm Houses in Bangladesh

Rodent Population Estimates and Potential Stored Paddy Losses

Abstract: Between July 1984 and June 1985, in 240 village structures in a deepwater rice-growing area of the Tangail District of Bangladesh, traps were set for small mammals. During 8,112 trap nights in 12 monthly trapping periods, 563 small mammals were captured, including 409 house mice, 42 lesser bandicoot rats, 31 roof rats, and 81 Asiatic musk shrews. The initial population of small mammals in these structures was estimated at 2,107 from changes in activity indices that were determined by placing inked tracking tiles in the houses before and after removal trapping. The estimated rodent population per farm was 11.6. Based on laboratory tests of the food consumption of each species, this number of animals can cause a potential loss of 48 kg of stored paddy per farm family per year. House mice and roof rats mostly were active off the floors and in the upper parts of the structures. Bandicoot activity occurred both on the floors and on shelves and in food storage baskets. Musk shrews were most active on the floors. Animal numbers were highest in September through January, were least in February through May, and were moderate in June through August, correlating with the peaks in breeding activity of house mice.

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Issued May 1994

United States Department of Agriculture

Animal and Plant Health Inspection Service

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Rodent Population Estimates and Potential Stored Paddy Losses

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Introduction

The direct measurement of stored grain losses caused by rodents in farmers' houses is difficult, time consuming, and rarely attempted (Greaves 1978). The success of direct measurement is dependent on the complete cooperation of householders. A measured quantity of grain must be placed in the cooperating households, or the householders' own supply of stored grain must be accurately weighed, and each removal of grain for household use must be weighed. At the end of the trial, the grain must again be weighed, and samples must be examined to determine the amount of loss that can be attributed to insect damage and rodent consumption. Adjustments also have to be made to account for gain or loss of moisture in the grain. Another problem, particularly in Bangladesh, is that farmers hold harvested paddy (unhusked raw rice) for only a short time before selling it at the local markets. Stored grain amounts are constantly in flux. In a previous study, Mian et al. (1987) found farm families generally not interested in cooperating. For these reasons, we turned to indirect methods to estimate potential grain losses in farm households.

Techniques for estimating rodent populations are well established. The extent of stored grain losses depends upon the distribution, abundance, and species composition of the rodent populations involved. Using methods to estimate rodent populations from change in activity indices before and after removal trapping, and knowing how much grain each rodent species eats in 1 night, Mian et al. (1987) estimated stored food losses in farm houses in Bangladesh in an upland crop-growing area.

The Mian team's findings of rodent numbers per farm family compare favorably with many estimates from India (Chaturvedi 1977, Krishnamurthy et al. 1967, Rao et al. 1977) but differ in that investigators there found the roof rat *(Rattus rattus)* was the predominant house-dwelling rodent. The Mian team found the house mouse *(Mus musculus)* to be the predominant rodent in farm houses in Bangladesh. Near the end of their study, Mian et al. found that much of the rodent activity was not on the floor of the houses but was concentrated up on the shelves, platforms, and lofts (called collectively "machas") and in the storage containers (called "dholes"). To attempt better rodent population estimates and a more accurate estimate of potential stored grain losses, we conducted a second 1-year study in farmers' houses and storage structures in a deepwater rice-growing area.

Methods

Study Site

The area studied is located 50 km west of the Bangladesh Agricultural Research Institute (BARI), Joydebpur, in a deepwater rice-growing part of Mirzapur Upazila, Tangail District. In this area, the villages are built on raised mounds of earth, standing about 3 to 5 m above the surrounding fields. During the monsoon rains, these villages become seasonal islands. The village islands are accessible only by boat during flood periods. When the study began In July 1984, the area was flooded from the early onset of monsoon rains a month before. Twenty households in a village were selected each month for study (12 villages × 20 households = 240 households). The selection was not random: households were selected on the basis of the householders' agreement to cooperate in the study. The 240 farm households comprising 372 structures (main living quarters plus separate kitchens and other structures) were sampled by trapping, physical inspection, and householder interview.

Tracking Tiles and Trapping

Inked vinyl tracking tiles (15 by 15 cm) were placed in each household for 1 night, setting four on the floor, two on the macha, and two in each dhole that contained stored paddy. Depending on how many dholes were available, a minimum of eight tracking tiles was placed in each house. The Mian team found that small mammals did not show neophobic reactions to the tracking tiles and that there was no significant difference between the number marked on the first and the second nights. Tiles were scored as either positive or negative the following morning. Then rat and mouse snap-traps were set in each house for 3 nights. A minimum of 10 traps was set per house: 2 rat and 4 mouse traps on the floor, 1 rat and 1 mouse trap on the macha, and 1 rat and 1 mouse trap in each dhole containing paddy. The tracking tile procedures were changed in January 1985 in order to give more attention to the macha area by placing 2 more tiles and 2 more mouse traps in the macha areas each night, giving a minimum of 10 tiles and 12 traps per farm structure per night, the exact number depending upon how many dholes had stored paddy. Trapped animals were collected each morning, and sprung traps were reset. Traps were baited with dried fish. We set traps and removed catches for 3 successive nights. After trapping, tiles were again set for 1 night.

Results

Population Estimates

The original small-mammal populations were estimated by the "change-in-ratio" method (Davis and Winstead 1980), using the formula

$$(T_1 - T_2)/n = T_1/N_1 = T_2/N_2,$$

where n is the number of animals captured, N_1 is the population before removal and N_2 after removal, T_1 is the percent of tiles positive for tracks before trapping, and T_2 is the percent positive after trapping. The method is simple but assumes that the ratio of counted objects (number or percent of tracked tiles) to the animals captured is the same both times. This may hold true for the short time periods involved (only 4 days). Mian et al. (1987) found this method to be the most reliable of three methods of population estimation tested.

The number of active bandicoot rat burrows in each trapped household was noted monthly when the traps were set from August onward.

Quantities of Stored Paddy

The quantities of stored paddy were recorded each month for each household according to the farmers' estimates, which we verified from examining the paddy baskets. Paddy baskets come in several sizes according to how many maunds (approximately 40 kg) of paddy they will hold.

House Mouse Breeding

All trapped house mice were returned to the laboratory, where they were weighed, measured, and necropsied. Reproductive data were recorded on both sexes, noting especially the visible pregnancies. Males ≥ 10 g in body weight were sexually mature based upon the presence of visible tubules in the cauda epididymis. Females ≥ 11 g in body weight were sexually mature based upon the presence of corpora lutea in the ovaries. All others were classified as immatures. The proportion of females visibly pregnant was based only on sexually mature adults.

Animal Captures

In all, 563 small mammals were captured during 8,112 trap nights in the 12 monthly trapping periods (table 1), of which 72.6 percent (409) were house mice, 14.4 percent (81) were Asiatic musk shrews *(S. murinus),* 7.5 percent (42) were lesser bandicoot rats *(B. bengalensis),* and 5.5 percent (31) were roof rats. House mice were captured every month, shrews were captured every month except March, and roof rats and bandicoot rats were captured sporadically.

Tracking Tile Activity and Population Estimates

Based on tracking tile indices before and after trapping and number of animals removed, estimated small-mammal populations were highest for September through January (table 2). Populations were estimated to be lowest February through May. The monsoon months of June through August appeared to have moderate levels. The estimated animal population before removal trapping of 563 small mammals was 2,107.

Relative Animal Densities From Trapping Effort

Relative densities of small mammals, as determined from captures per unit trapping effort, varied from a high of 12.5 per 100 trap nights in September to a low of 2.4 per 100 trap nights in May (table 3). Relative densities were highest from September through January, then dropped to an annual low during February through May. Densities were at moderate levels during the monsoon months of June through August.

A progressive decline in number of animals captured during the 3-day trapping period occurred in 8 of the 12 trapping episodes. In July, captures were highest on the second day. In August, September, and February, most animals were captured on the third day.

Infestation Levels

Infestation levels were recorded from (1) trapping data, (2) activity at tracking tiles before trapping, and (3) (for lesser bandicoot rats) from the presence of burrows inside the houses (table 4). Tracking tiles gave a higher index of infestation than traps, probably because of differing reactions by small mammals to tiles versus snap-traps.

Village houses are built on raised earth foundations standing about 0.5 meter higher than the island. Bandicoot rats construct elaborate burrow systems in the earth foundations and emerge through the floor in the house, frequently under the platforms that hold the dholes. Burrows of lesser bandicoot rats were seen in 60.5 percent of the houses, indicating an average of 12.1 houses infested per month. No data on burrow

numbers were recorded in July. Lesser bandicoot rats were captured in only 7.5 percent of the houses during the 12 months, indicating that this species was not trapped in proportion to its presence or its numbers. Roof rats were taken in 24 houses (10 percent), and house mice in 167 houses (69.6 percent).

Place of Capture

Household interiors were divided into three vertical zones to measure tracking-tile and trapping activity: on the floor, on machas, and in dholes (table 5). Roof rats, rarely captured on the floor, apparently spent much of their time on the machas, and almost 20 percent were taken in dholes. House mice appeared to use the entire house interior, but similar to roof rats, most of their activity occurred above the floor. About 20 percent of the mice were captured in dholes. Lesser bandicoot rats spent most of their time on the floor but did get onto machas and into dholes. Musk shrews are poor climbers: 90 percent were taken on the floor, 10 percent on machas, and none in dholes. A chi-square test of the data in table 5 indicated that there was a significant difference between the places of capture of the several species ($\chi^2 = 203.2$, $p < 0.01$).

The number of animals captured in dholes was 16.5 percent of the total; those captured on machas made up almost 54 percent of the total, indicating that about 70 percent of small-mammal activity takes place off the floor. Data from tracking tiles strongly support the trapping results (table 6). In a total of 699 tiles scored as positive, 164 (24 percent) were in dholes, 296 (42 percent) on machas, and 239 (34 percent) were on the floor. When the tile data are adjusted for the proportion of tiles set in each zone, the percent positive rises to 35 percent in dholes and 51 percent on machas. Only 25 percent of the tiles set on floors were positive.

Quantities of Stored Paddy

The average quantities of stored paddy in the 20 houses surveyed each month ranged from 1,305 kg in May to 0 in March and April (table 7). These are the farmers' estimates as verified by our visual examination. We made no actual measurements of the amounts. No data were recorded in July, the first month of the study.

This deepwater rice-growing area has essentially two crops per year, the boro (winter/spring) crop and the aman (summer/fall) crop. The large quantity in storage in August and September was from the boro (spring) rice harvest in May and June. Quantities declined in October and November, when stocks were either sold or eaten. Quantities increased in December because of the harvest of the aman (fall; transplanted and deepwater rice) crop. However, this harvest was reduced to about 80 percent below normal because much of the aman crop was never planted due to premature flooding in June 1984 and what was sown was flooded out because of deeper than normal water levels during the growing season (July through September 1984). The limited quantities of harvested rice were quickly sold in January and February; no rice was in storage by March. This condition persisted until the next boro harvest in May and June.

House Mouse Breeding

The proportions of adult female house mice visibly pregnant in the monthly samples are detailed in table 8. Because some months yielded only small samples, we smoothed the crude proportions pregnant by converting to a 3-month moving average. Two peaks in pregnancies occurred: one in October through January and another in April through June. Immature mice appeared in the greatest proportions in samples in July through October. For some reason we can't explain, they failed to appear in quantity following the peak pregnancies of October through January.

Discussion

Animal Captures

House mice were the predominant rodent species in farm households, comprising 72.6 percent of all captures. In the Mian team's previous study in another part of Bangladesh, house mice comprised 53 percent of total captures. Methods in the two studies differed: in the former, traps were set outdoors and more shrews were caught, lowering the proportion of house mice captured. In our study, traps were placed in areas that mice frequent. The proportion of roof rats and bandicoot rats captured was almost identical in the two studies.

Our findings on species proportions in farm houses differ from studies in India. There, roof rats almost uniformly predominate in rural housing, with a small proportion of house mice and bandicoot rats. The musk shrew is an important member of the rural household fauna in Asia but probably plays little or no role in stored food losses.

Removal trapping reduced overall tracking-tile activity by 33 percent. Much of the population left behind was house mice, as attested by the prints on the tracking tiles. Many other prints were those of bandicoot rats. While active bandicoot burrows were seen in 133 houses out of 220 checked, bandicoots were captured in only 15 of these burrow-positive houses. Five bandicoots were trapped in three houses that had no burrows. We believe that bandicoot rats were underrepresented in the captures.

Animal Estimates

The estimated animal populations before removal trapping of 563 small mammals was 2,107: 1,531 *M. musculus,* 157 *B. bengalensis,* 116 *R. rattus,* and 303 *S. murinus.* These estimates are based upon the proportion of each species in the total catch. As noted above, these numbers were undoubtedly low for *B. bengalensis* and *M. musculus.* However, accepting these figures, we calculated that there were 7.5 rodents per structure (1,804 rodents in 240 structures). Since each farm family averaged 1.55 structures, the estimated rodent population per farm family is 11.6 (9.9 house mice, 1.0 bandicoot, 0.7 roof rat).

Krishnamurthy et al. (1967) estimated rodent numbers per house close to those in Mian's and our studies. Krishnamurthy's team estimated 8.2 rodents per house (mostly *R. rattus* but some *M. musculus).* Their results were based upon capture–mark–recapture (CMR) methods. Other methods, based upon rodents picked up dead following poisoning campaigns, have provided estimates ranging from 4.9 rodents per house (Rao et al. 1977) to 10.4 rodents per house in the village of Karli, India (Chaturvedi 1977). The findings in our study are most similar to those in Mian et al. (1987), where the species composition was the same, the number of rodents per farm household was estimated at 10.3, and the potential stored food grain losses were estimated at 53 kg per farm household per year. Seasonal fluctuations in small-mammal populations occurred, with peak numbers in September through February and again in May through July. The peaks in abundance of rodents in both studies were related to the periods of harvest and storage of paddy in the farm households. These peaks were mainly due to changes in house mouse numbers.

Seasonal Fluctuations

The fluctuations in numbers of small mammals in Bangladeshi farmers' houses are mainly a result of the numbers of house mice captured each month. In the peak months, September through January, monthly captures of house mice averaged 50 or more except for November. During the remaining months of the study, numbers of house mice captured varied from 11 to 30. Fluctuations in mouse populations were due to the breeding taking place April through June and October through January. Immature mice were present in greatest abundance in August and September, probably products of a first reproductive peak following the boro rice harvest.

Activity

As suspected, the activity of small mammals within the studied households was highly compartmented. House mice and roof rats showed similar activity patterns, heavily utilizing the machas and dholes. However, mice used the floor to a greater extent than roof rats. Lesser bandicoot rats, living in burrows in the floor or foundation, were mostly active on the floor but also used machas and dholes when searching for food. Musk shrews mainly were active on the floor. Only 10 percent were captured on machas and none in dholes.

Potential Stored Food Losses

The estimated rodent population per farm family was found to be 9.9 house mice, 1.0 bandicoot rat, and 0.7 roof rat. Using daily consumption of paddy (determined from laboratory studies carried out at the Vertebrate Pest Section, BARI) of 3, 9, and 19 g for *M. musculus, R. rattus,* and *B. bengalensis,* respectively, the daily amount of paddy consumed by rats and mice in a farm household would equal 55.5 g. Because bandicoot rats hoard at least four times their average daily consumption (Parrack 1969), hoarding would add 76 g, giving an average daily loss of paddy of 131.5 g of paddy per farm family, or an annual loss of 48 kg. This is a minimum amount since populations of both house mice and bandicoot rats were apparently underestimated.

Acknowledgments

We thank Steven A. Shumake and G. Keith LaVoie, Denver Wildlife Research Center, for reviewing the manuscript. This study was financially supported by the Bangladesh Agricultural Research Institute and the U.S. Agency for International Development under the Project "Agricultural Research, Vertebrate Pest Component, PASA IBD-0051-IF-2252-03."

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Table 1—Small-mammal species captured from farmers' houses in Tangail District, Bangladesh, 1984–85.

Month	*B. bengalensis*	*R. rattus*	*M. musculus*	*S. murinus*	Total
Jul	0	4	30	5	39
Aug	6	0	27	12	45
Sep	19	1	53	4	77
Oct	0	2	55	15	72
Nov	8	5	44	5	62
Dec	3	6	62	9	80
Jan	0	4	50	11	65
Feb	1	1	14	3	19
Mar	0	0	24	0	24
Apr	0	3	11	4	18
May	0	0	12	5	17
Jun	5	5	27	8	45
Total	42	31	409	81	563
Percent	7.5	5.5	72.6	14.4	

Table 2—Tracking-tile activity, animals removed, and estimated original small-mammal populations

Month	Percent positive		Animals removed	Estimated original population
	Pretrapping tile activity	Posttrapping tile activity		
Jul	41.2	18.6	39	71
Aug	47.2	28.3	45	112
Sep	56.0	48.2	77	553
Oct	55.1	39.2	72	249
Nov	36.9	26.7	62	224
Dec	34.8	27.0	80	357
Jan	24.4	14.6	65	162
Feb	20.6	9.4	19	35
Mar	21.2	13.8	24	69
Apr	26.9	18.8	18	60
May	29.2	15.0	17	35
Jun	26.2	19.6	45	180
Total	35.0	23.3	563	2,107

Table 3—Animal captures per day and per unit trapping effort

Month	Days 1	2	3	Total captures	Trap nights	Captures/100 trap nights
Jul	14	15	10	39	636	6.1
Aug	21	9	15	45	660	6.8
Sep	29	22	26	77	618	12.5
Oct	30	23	19	72	648	11.1
Nov	25	22	15	62	636	9.7
Dec	31	26	23	80	648	12.3
Jan	33	17	15	65	732	8.9
Feb	8	5	6	19	714	2.7
Mar	14	6	4	24	714	3.4
Apr	9	6	3	18	654	2.7
May	9	6	2	17	708	2.4
Jun	18	17	10	45	744	6.0
Total	241	174	148	563	8,112	

Table 4—Infestation levels of small mammals in farmers' houses (n=240) as measured by several methods

Month	Number of positive houses: By positive tracking tiles	By trapping: Rodents	Shrews	Both	By active bandicoot burrows
Jul	20	14	3	17	—
Aug	20	12	9	16	14
Sep	20	18	3	18	19
Oct	20	18	7	18	16
Nov	20	17	4	17	13
Dec	20	18	7	19	17
Jan	18	17	7	19	13
Feb	17	10	2	11	5
Mar	17	15	0	15	4
Apr	19	11	3	13	10
May	18	10	5	12	5
Jun	19	16	5	18	17
Total	228	176	55	193	133
Mean	19.0	14.7	4.6	16.1	11.1

Table 5—Place of capture of small mammals in farmers' houses

Place	Number captured				Total
	R. rattus	*M. musculus*	*B. bengalensis*	*S. murinus*	
Dholes	6	82	5	0	93
Machas	23	260	12	8	303
Floor	2	67	25	73	167
Total	31	409	42	81	563

Table 6—Small-mammal activity at tracking tiles set inside farmers' houses

Place	Tiles set	Positive tiles		Proportion of all positive
		Number	Percent	
Dholes	468	164	35.0	0.235
Machas	584	296	50.7	0.423
Floor	960	239	24.9	0.342

Table 7—Quantity (kg) of stored paddy in farm households

Month	No. houses with paddy	Total paddy stored	Paddy per household
Jul	—	—	—
Aug	20	22,305	1,115
Sep	20	22,230	1,111
Oct	20	12,533	627
Nov	19	11,861	624
Dec	20	19,321	966
Jan	9	2,760	307
Feb	4	970	242
Mar	0	0	0
Apr	0	0	0
May	15	19,582	1,305
Jun	19	13,950	734

— = No data.

Table 8—Visible pregnancies in adult female house mice trapped from farmers' houses

Month	No. females examined	No. visibly pregnant	Percent pregnant	3-month moving average
Jul	7	3	42.8	38.1
Aug	4	2	50.0	34.8
Sep	12	3	25.0	30.0
Oct	14	4	28.6	47.7
Nov	18	14	77.8	54.3
Dec	14	7	50.0	55.9
Jan	27	12	44.4	44.4
Feb	4	1	25.0	38.5
Mar	8	2	25.0	30.8
Apr	1	1	100.0	42.9
May	5	3	60.0	43.7
Jun	10	3	30.0	40.9
Total	124	55	44.3	—

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